Autonomic Nervous System

Autonomic ganglia

- **A ganglion** is a collection of neurons outside the CNS.
- Each preganglionic fiber synapses with 8-9 cell bodies of postganglionic neurons.
- **Act as distributing centers**: each preganglionic nerve fiber stimulates 8-9 postganglionic neurons (limited origin relative to multiple supplied organs).

1) Paravertebral ganglia (lateral = sympathetic chain):

- A pair of ganglia on either sides of each segment of spinal cord
- Cervical region (3 only: superior, middle, inferior).
- For relay of sympathetic only.

2) Collateral ganglia:

- present at origin of big vessels from abdominal aorta
- named according to the vessel
- sympathetic: coeliac, superior, inferior mesenteric ganglia
- parasympathetic: ciliary, sphenopalatine, submaxillary, otic ganglia

3) Terminal ganglia:

- present near or inside the organ
- very short postganglionic
- For relay of parasympathetic only

4) Adrenal medulla:

- Modified Sympathetic ganglia.
- postganglionic cells have lost their axons → secrete catecholamines into blood
- Supplied by preganglionic cholinergic neurons of lower 6 thoracic LHCs
- Cells are stimulated by acetyl choline and secrete catecholamines

Sympathetic Nervous System thoracolumbar

I- Head & Neck: **Origin:** preganglionic fibers arise from LHCs of T1-2	**Functions:** **1) Eye:** a. Pupil dilatation = mydriasis (contraction of dilator pupillae ms) b. Elevation of upper eye lid c. Exophthalmos (contraction of Muller muscles → in animals). d. Relaxation of ciliary muscle → ---- lens power to see far objects e. VC of conjunctival vessels & ---- lacrimal secretion

Relay: cervical lateral ganglia Postganglionic fibers run within the spinal nerves	**2) Skin:** a. +++ sweat gland secretion b. VC (vasoconstriction) of blood vessels c. Hair erection by contraction of piloerector muscles **3) Salivary glands:** a. small trophic viscid secretion b- VC of blood vessels **4) Cerebral vessels:** mild VC but +++ Cerebral blood flow due to +++ ABP
II- Thorax: **Origin:** LHCs of T1,2,3,4 **Relay:** cervical & upper 4 thoracic ganglia in sympathetic chain	**Functions:** **1) Heart :** a. +++ excitability b- +++ rate of conduction c- +++ force of contraction d- +++ heart rate e- VD of coronary vessels (indirect effect) **2) Lung** a- bronchodilatation b- VC of pulmonary vessels
III- Abdomen: **Origin:** LHCs of T7,8,9,10,11,12 **Course:** preganglionic fibers: Greater splanchnic nerve **Relay:** collateral ganglia: coeliac & superior mesenteric.	**Functions:** **1) Liver:** glycogenolysis → hyperglycemia & +++ metabolic rate. **2) Spleen:** contraction of its capsule → +++ RBC into circulation **3) Adrenal medulla:** 80% adrenaline & 20% noradrenaline **4) Gastrointestinal tract:** a. relaxation of plain muscle of stomach, small intestine & proximal part of large intestine b. contraction of sphincters e.g. pyloric sphincter **5) Blood vessels:** a. VC of blood vessels of abdominal viscera b. VD of some arterioles of abdominal viscera **6) Kidney:** ---- urine volume & +++ rennin
IV- Pelvic viscera: **Origin:** LHCs of T12, L1,2,3 **Course:** preganglionic fibers: Lesser splanchnic nerve	**Functions:** **1) GIT (distal colon & rectum):** retention of feces a. inhibition of plain muscles of wall of rectum b. contraction of internal anal sphincter **2) Urinary bladder:** retention of urine a. contraction of internal urethral sphincter b. inhibition of plain muscles of wall of bladder. **3) Male genitalia:**

Relay: collateral ganglia: inferior mesenteric ganglia	a. contraction of vas deferens, seminal vesicle & prostate→ ejaculatio b. VC → shrinkage of penis **4) Female genitalia**: variable effect (according to menstrual cycle) **5) Blood vessels:** mainly VC of blood vessels of pelvic viscera.

Horner Syndrome:

- Lesion in cervical sympathetic chain on one side
- Manifestations are present **on diseased side only**

  a- **Miosis:** constriction of pupil

  b- **Ptosis:** drop of upper eye lid

  c- **Anhydrosis:** no sweating on that side → dry skin

  d- **Warm & red skin:** due to VD of blood vessels

Parasympathetic Nervous System craniosacral

1) Occulomotor (3rd cranial nerve):

Origin: pre ganglionic fibers → arise from Edinger-Westphal nucleus of midbrain

Relay: ciliary ganglion

Course: post ganglionic → short ciliary nerves

Function:

a. pupil constriction = miosis (contraction of constrictor pupillae muscle)

b. contraction of ciliary muscle → +++ power of lens for near vision

2) Facial (7th cranial nerve):

Origin: pre ganglionic fibers arise from superior salivary nucleus in pons

Relay: sphenopalatine ganglion → supply nasal & lacrimal glands

Chorda tympani (branch of facial nerve) **relay** in submandibular ganglion → supply submandibular & sublingual glands

Functions:

- secretomotor & VD to the glands

3)Glossopharyngeal (9th cranial nerve)

Origin: pre ganglionic fibers arise from inferior salivary nucleus in medulla

Relay: otic ganglia

Functions: secretomotor & VD to parotid glands

4)Vagus (10th cranial nerve)

Origin: pre ganglionic fibers arise from Vagal nucleus in medulla

Relay: terminal ganglia

Functions:

a)- Thorax:

- Heart: i. ----- all atrial properties (NO vagal supply to ventricles)
  ii. ----- coronary flow   iii. ---- O_2 consumption
- Lungs: i. bronchial constriction
  ii. VD of pulmonary vessels   iii. +++ bronchial secretion

b)- Abdomen:

- GIT: i.Motor to esophagus, stomach, small intestine, proximal large intestine
  ii. inhibitory to sphincters
  iii. Secretory to glands of stomach, small intestine, liver, pancreas
- Gall bladder: motor to wall & inhibitory to sphincters of oddi (evacuation)

5)- Sacral outflow (Function on pelvic viscera):

Origin: S-2-3-4

Course: Pelvic nerve (nerve erigentes)

Relay: terminal ganglia.

Functions:

- Defecation: i. +++ wall of rectum   ii. ----- internal anal sphincter
- Micturition: i. +++ wall of urinary bladder   ii. ---- internal urethral sphincter
- Male genitalia: i. erection (VD)   ii. +++ Secretions of seminal vesicle & prostate
- Female genitalia: VD

Chemical transmission in autonomic nervous system

Acetyl Choline secreted by Cholinergic fibers	Noradrenaline = Norepinephrine secreted by Adrenergic fibers
Removal of acetyl choline: • Acetyl choline → splitted by acetyl choline esterase → Acetate + choline • Choline → transported back into nerve endings → new Ac.ch • **Acetyl choline esterase is 2 types:** **a- True (specific):** has great affinity for acetyl choline, present in membranes of cholinergic nerve endings & synaptic area **b- Pseudo (non specific):** in plasma, acts on diffused acetyl choline into plasma	**Removal of norepinephrine:** Removed within few secs by 3 ways: 1- Active Reuptake into nerve endings (50-80% of released NE) 2- Diffusion to ECF then to blood. 3- Destruction by: i- deamination by MAO (monoamine oxidase) in nerve endings & tissues ii- methylation by COMT (catechol-O-methyl transferase) in tissues **except** nerve endings

Sites of cholinergic fibers:	Sites of adrenergic fibers:
1-All preganglionic symp & parasymp fibers 2- All postganlionic parasympathetic fiber 3- Some postganglionic sympathetic → sweat gland & blood vessel of skeletal muscles 4- All neuromuscular junction & CNS	• **All** postganglionic sympathetic fibers **except** sweat gland & blood vessels of skeletal muscles
Cholinergic receptors: **1)Peripheral cholinergic (Muscarinic):** • Found in effector organs supplied by: a- all postganglionic parasympathetic b- some postganglionic sympathetic (sweat gland & blood vessels of skeletal muscles • Named muscarinic (muscarine stimulate them **2) Central cholinergic (Nicotinic):** • Found on membrane of all postganglionic fibers at autonomic ganglia. • Named nicotinic (nicotine stimulates them)	**Adrenergic receptors:** **1) Presynaptic adrenoceptors:** • Present on membrane of postganglionic nerve endings • They are 2 types (alpha & Beta) • Autoreceptors regulating the release of NE • Stimulation of α receptors → --- NE • Stimulation of β receptors → +++NE 2) **Postsynaptic Adrenoceptors:** present on different effector organs • **Types:** α & β recept (see next table)

Types	α adrenergic receptors α1, α2	β adrenergic receptors β1 & β2
Mechanism of action	α1 → +++ intracellular Ca^{++} α2 → --- adenyl cyclase → --- cAMP	Both **β1** & **β2** → +++ adenyl cyclase → +++ cAMP
Site & Action	**Mainly excitatory: contraction of:** 1- Blood Vessels → VC 2- dilator pupillae 3- Spleen capsule 4- seminal vesicles & vas deferenes 5-GIT & internal urethral **sphincter** **Except** small intestinal wall → inhibition	**Mainly inhibitory: relaxation of:** 1- Blood vs of skeletal ms (β2) → VD 2- Bronchi (β2) → bronchodilatation 3- Urinary bladder 4- Uterus 5- GIT wall 6- lipolysis **Except** : Heart (β1) → stimulation

Adrenal Medulla

A modified sympathetic ganglion in which postganglionic neurons lost their axons → secrete → adrenaline (80%), noradrenaline (20%). **These hormones:**

- circulate in blood → reach all tissues → same effect as sympathetic
- prolonged effects (5-10 minutes) (removed from blood slowly)

Adrenaline	Noradrenaline
excites α & β equally	excites α more than β

greater effect on cardiac (β-receptor) function & on metabolism	**greater effect on arterial blood pressure (VC) (α-receptor)**

Alarm"Stress" response of sympathetic nervous system:

Sympathetic system prepares the body for emergency (flight, fight, fright = fear)

Sympathetic is catabolic (energy consuming)

Parasympathetic is anabolic (energy preserving)

1. **Lung:** Bronchodilatation → better ventilation (oxygen)
2. **Liver:** Glycogenolysis → increase glucose in blood i.e. hyperglycemia.
3. **Lipolysis:** Free fatty acids are increased in blood.
4. **Cardiovascular system:** +++ heart rate, force & blood pressure → better perfusion
5. **Lowers the threshold in reticular formation** in brain → alert & aroused.
6. **Increase fibrinogen** & VC of skin bl.vs → limit bleeding if wounded.
7. **Increase field of vision:** pupil dilatation & elevation of upper eye lid.

Autonomic Drugs

Drugs augment parasympathetic:	**Drugs depress parasympathetic:**
1- Ganglion stimulants • Nicotine small dose • Anticholine esterases: - prostigmine ; DIPF	**1- Ganglion blockers** • Nicotine large dose • Tetraethylammonium (TEA)
2- Parasympathomimetic drugs: • Muscarine; Pilocarpine • Anticholine esterase drugs	**2- Parasympatholytic drugs:** • Atropine
Drugs augment sympathetic	**Drugs depress sympathetic**
1- Ganglion stimulants: (Same)	**1- Ganglion Blockers: (Same)**
2- Sympathomimetics: Drugs stimulate α receptors: Phenylephrine Drugs stimulate β receptors: Isoprenaline	**2- Sympatholytics** block α receptors: Phentolamine block β receptors: Inderal (propranolol)